



Atmosphere Learning Progression

Grades 9-12: GLOBE Protocols Aligned with NASA Resources and NGSS Standards



**NGSS Disciplinary Core Ideas Progression of Learning:** Building on the concepts developed in grades 6-8, students in grades 9-12 will examine the relationship between the Sun’s radiation and its interactions with the Earth system, in particular the atmosphere, recognizing the ocean and land as the foundation of the global climate system. Global climate models, developed by scientists and mathematicians, are used to predict future changes, including changes related to human impacts and natural factors. Using GLOBE and MY NASA DATA educators and students will access NASA satellite data to examine a variety of Earth system interactions.

**Access this Progression online at the NASA Langley GLOBE Resource Page:** [www.globe.gov/web/nasa-langley-research-center/home/resources](http://www.globe.gov/web/nasa-langley-research-center/home/resources)

<p><b>Performance Expectations:</b></p> <p><b>HS-ESS2-2</b> Analyze geoscience data to make the claim that one change to Earth’s surface can create feedbacks that cause changes to other Earth systems.</p> <p><b>HS-ESS2-4</b> Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate.</p> <p><b>HS-ESS3-5</b> Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts on Earth systems.</p> <p><b>HS-LS2-7</b> Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.</p>		
<p><b>NGSS Science Practices:</b></p> <p><b>Asking Questions and Defining Problems:</b> Ask questions to identify and clarify evidence of an argument.</p> <p><b>Developing and Using Models-</b> Develop and use a model to describe phenomena.</p> <p><b>Analyzing and Interpreting Data:</b> Analyze data using computational models in order to make valid and reliable scientific claims.</p>	<p><b>NGSS Disciplinary Core Idea:</b></p> <p><b>ESS2.A: Earth Materials and Systems:</b> Earth’s systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.</p> <p><b>ESS2.D: Weather and Climate:</b> The foundation for Earth’s global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy’s re-radiation into space.</p> <p><b>ESS1.B: Earth and the Solar System:</b> Cyclical changes in the shape of Earth’s orbit around the sun, together with changes in the tilt of the planet’s axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes.</p> <p><b>ESS2.A: Earth Materials and Systems:</b> The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun’s energy output or Earth’s orbit, tectonic events, ocean circulation, volcanic activity, glacial cycles, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.</p>	<p><b>NGSS Crosscutting Concepts:</b></p> <p><b>Stability and Change</b> Feedback (negative or positive) can stabilize or destabilize a system.</p> <p><b>Cause and Effect</b> Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</p>
<p><b>GLOBE Alignment: Environmental observations, data collection and learning activities to develop Earth science concepts.</b></p>		
<p><b>Atmosphere Protocols:</b></p> <p><a href="#">Air Temperature</a></p> <p><a href="#">Aerosols</a></p> <p><a href="#">Clouds</a></p> <p><a href="#">Surface Temperature</a></p> <p><a href="#">Precipitation</a></p> <p><a href="#">Wind</a></p> <p><b>Data Investigation Sheets:</b></p> <p><a href="#">Atmosphere Investigation Integrated 1-Day</a></p> <p><a href="#">Atmosphere Investigation Clouds 1-Day</a></p> <p><a href="#">Atmosphere Investigation Surface Temperature</a></p>	<p><b>GLOBE Learning Activities:</b></p> <ol style="list-style-type: none"><li><a href="#">RC2: Effects of Inputs and Outputs on a Region</a> (HS-ESS2-2, HS-ESS2-4)</li><li><a href="#">Seasonal Change on Land and Water</a> (HS-ESS2-4)</li><li><a href="#">LC5: Comparing the Study Site to One in Another Region</a> (HS-ESS2-4)</li><li><a href="#">GC2: Components of the Earth System Working Together</a> (HS-ESS2-2, HS-ESS2-4)</li><li><a href="#">Getting to Know Global Carbon</a>(HS-LS2-7)</li><li><a href="#">Carbon Cycle Adventure Story</a> (HS-LS2-7)</li></ol> <p>Math Connection: <a href="#">LC3-Using Graphs to Show Connections</a> (HS-ESS2-2)</p>	<p><b>Guiding Question(s):</b></p> <ol style="list-style-type: none"><li>How can satellite data in combination with ground truth observations be used to identify trends and patterns associated with interactions that occur between the different Earth systems?</li><li>How do variations in the flow of energy into and out of Earth’s systems result in changes in climate?</li><li>Based on evidence from satellite data, what factors are associated with the rise in global temperatures over the past century? Which of these factors can be attributed to human impacts? To natural hazards?</li><li>How does the carbon cycle fit into climate change? How should this information be shared with the general public?</li></ol>
<p><b>NASA Resources: Data and lessons drawn from NASA’s Earth science research program</b></p>		
<p><b>NASA Extension Learning Activities/Resources:</b></p> <p><a href="#">NASA Climate Change Educational Modules</a></p> <p><a href="#">NASA Earth Observatory World Maps</a></p> <p><a href="#">NASA Wavelength Learning Resource List</a></p>	<p><b>My NASA Data Visualization Tool:</b></p> <p><a href="#">Earth System Data Explorer</a></p> <p><b>MY NASA DATA Variable Suggestions:</b></p> <p><b>Air Temperature:</b> <a href="#">Monthly Near-Surface Air Temperature (ISCCP)</a></p> <p><b>Aerosols:</b> <a href="#">Monthly Aerosol Optical Depth (MISR)</a></p> <p><b>Clouds:</b> <a href="#">Monthly Cloud Coverage (CERES TERRA)</a></p> <p><b>Surface Temperature:</b> <a href="#">Monthly Surface Skin Temperature (CERES)</a></p> <p><b>Precipitation:</b> <a href="#">Monthly Precipitation (GPCP)</a></p> <p><b>Wind:</b> <a href="#">Monthly Near Surface Wind Speed (QuickSCAT)</a></p>	<p><b>My NASA Data Lessons/Activities:</b></p> <p><a href="#">Earth’s Energy Budget-Seasonal Cycles of Net Radiative Flux</a> (HS-ESS2-4, HS-ESS3-5)</p> <p><a href="#">Tropical Atlantic Aerosols and Cloud Cover</a> (HS-ESS2-2)</p> <p><a href="#">Math Connection - Creating and Analyzing Graphs of Tropospheric Ozone</a> (HS-LS2-7)</p>



